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museums, but since they cannot, the person who has formed a private collection can most successfully manage one for the use of the public, since he better than anyone else is able, in considering the needs of the museum visitor, to keep in mind that saying which is so useful a guide in museum practice—'Put yourself in his place.'

G. BROWN GOODE.

THE X-RAYS.

HELMHOLTZ, Hertz and Kundt, the three greatest physicists of modern Germany, have died within two years, and the friends of German science feared that this loss would be followed by a standstill in physics, or at least by a lack of really important discoveries. But now we have Professor W. Röntgen's investigations in the physical laboratory of the University in Würzburg, the importance of which does not stand behind the famous electrical discoveries of Hertz in Bonn. Röntgen has found a new kind of rays—he calls them the X-rays—which, though invisible to the eye, affect the photographic plate; which produce fluorescent phenomena; which pass through wood, metal and the human body; which are neither broken by prism and lenses nor reflected.

The chief facts about the X-rays are the following: It is well known that the discharges of a large Ruhmkorff induction coil produce in a vacuum tube, such as Crookes' or Hittorf's, colored rays which go in straight lines from the cathode to the glass of the tube. These cathode rays, which have been much studied, are visible to the eye and are well characterized by the fact that the magnet changes their direction; they do not pass thick cardboard, wood, etc. The place where these cathode rays reach the glass of the tube is the centre of Röntgen's X-rays. They are not visible and are not turned aside by a magnet; in short, they are not cathode rays, but are produced by them. If in a dark room we cover the tube by thin, black cardboard, nothing can be seen at all, even if we bring the eye in the direct neighborhood of the tube during the electric discharges. But if we now bring a card covered with barium platinocyanide near it the paper flashes up with every discharge, and this fluorescent effect is visible even if the paper is distant 2 meters from the tube, and it does not matter whether the varnished or the other side of the paper is directed towards the tube. The X-rays thus go through the black cardboard which is opaque to sunlight, and the same effect follows when a bound volume of a thousand printed pages is put between the tube and the fluorescent paper. We can measure the perviousness of the different substances to the new rays by the intensity of the light on the paper, comparing the effect with and without objects between the tube and the fluorescent surface. But there is also an objective way possible to study the perviousness, as the rays produce an effect upon photographic dry plates, which, of course, remains and allows us to control the subjective comparisons. Both methods show that wood is not much less pervious than paper; boards 3 cm. thick absorb very little. Hard rubber disks several centimeters thick do not stop the rays, and even aluminium plates 15 mm. thick do not make the fluorescence entirely disappear. Glass plates vary with the lead in them, those containing lead being less pervious. Platinum is slightly pervious, if the plate is not thicker than 0.2 mm., silver and copper can be a little thicker; lead plates 1.5 mm. thick are no longer pervious. All substances become less pervious with increasing thickness, a fact which is nicely demonstrated by photographs taken through tinfoils of gradually increasing number. The perviousness of substances of equal thickness seems chiefly dependent on the density, but

special experiments showed that different metals are not equally pervious if the product of thickness and density is equal; the perviousness of platinum 0.018 mm. thick and a density of 2.15 equals that of lead 0.05 mm. thick, density 11.3 and that of tin 0.1 mm. thick, density 7.1, and that of aluminium 3.5 mm. thick and a density of 2.6. Aluminium may thus be 200 times thicker than platinum, while its density is one-tenth.

The fluorescent effect of the new rays is not confined to barium platinocyanide, but it occurs also on glass, calc-spar, rock-salt, etc. Prisms and lenses do not diffract the rays, nor do prisms of hard rubber or aluminium. With regard to reflection and diffraction the following experiment is interesting. It is well known that pulverized substances do not let pass much light owing to refraction and reflection. Röntgen found with pulverized salt, calc-spar, zinc and other substance that the ray pass through the powder with exactly the same intensity as through the solid substance. Objects with rough surface let it pass exactly like polished ones. The shadow of a round stick is in the middle darker than at the edges; the shadow of a metal tube is in the middle lighter than at the edges.

With regard to the effect on photographic plates, it must not be forgotten that lenses do not refract the rays and therefore ordinary photography is not possible; the pictures of the objects are only shadows. But these shadow-pictures can be taken in the closed wooden box of the camera in a light room, as the sunlight of course does not pass through the wood while the X-rays do. In this way Röntgen took photographs of a set of metal weights in a wooden box and of a thick wire wound as a spiral around a wooden stick; the wood was pervious, the metal of that thickness not, and so the shadows of the weights and of the wire are seen in the photograph, those of the wood scarcely at all. In the same manner he took the picture of a compass needle in the closed box. The door between two rooms did not hinder the chemical effect.

With regard to the nature of the X-rays it seems too early to say anything definite. Röntgen emphazises the fact that they show no refraction and probably therefore move in all substances with equal velocity and are transmitted by a medium which exists everywhere and in which are the molecules of the substances. That is they are ether rays, but not transverse ether waves like the visible or the ultra red or ultra violet invisible light; Röntgen supposes that they are longitudinal ether waves, the existence of which has for a long time been suspected by physicists. Researches regarding many other qualities of the new rays are in progress, and their results may clear up the theoretical interpretation.

It may be that the practical importance of the discovery is equal to the theoretical. It is well known throughout the world that the physical laboratories of Germany have no windows looking towards the patent office. The hunting for practical inventions is not usually important for theoretical science, but the progress of theory usually has practical applications. One practical result in this case is already clear, as the new rays pass boards but not thick metal plates, so they pass the organic substances of the human body, such as skin, muscles, etc., but not the bones. As the metal weights in the wooden box can be photographed, so can photographs of the human bones be taken. Röntgen has put his hand between the tube and the dry plate in the closed camera; the photograph shows clearly all the bones of the hand without the flesh and skin, and the gold rings seem to hang in the air. The value of such a method for medical diagnosis is clear. Fractures and diseases of bones can be examined by

photographic plates and metal pieces in the body, for example, needles, bullets, etc., can be found by this method. It will be a matter of the future to learn whether the rays have psycho-physiological effects.

The newspapers report that the whole thing was discovered by mere chance. Röntgen saw the effects on photographic papers which by chance were near to a covered tube during the discharge. This chance origin is not probable, as Lenard, the assistant of Hertz, has been working in the same direction for a long time, and many preparatory experiments by Röntgen himself cleared slowly the way. But suppose chance helped. There were many galvanic effects in the world before Galvani saw by chance the contraction of a frog's leg on an iron gate. The world is always full of such chances, and only the Galvanis and Röntgens are few.

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FREIBURG, BADEN, January 15, 1896.

SCIENTIFIC NOTES AND NEWS.

PROFESSOR RÖNTGEN'S DISCOVERY.

THE transmission through wood and other substances of the rays from a Crookes' vacuum tube, discovered by Prof. Röntgen, is reported to have been confirmed by Prof. Klupathy of Pesth, Prof. Domalip of Prague, Prof. Czermak of Gratz, and Mr. A. A. C. Swinton of London. The photographs have been exhibited before several scientific societies and by Prof. Röntgen to the Emperor of Germany, from whom he has received a decoration.

Mr. Swinton writes to the *Standard* that with Mr. J. C. M. Stanton he has obtained distinct proof that the radiations in question do pass easily through various substances that are quite opaque to ordinary light, and do produce strong impressions upon ordinary photographic plates entirely incased in light-proof material. Indeed, all substances that he has so far experimented on in his laboratory appear to be transparent to these radiations, even sheets of ebonite, carbon, vulcanized fibre, copper, aluminium and iron, though there is considerable variation in degree. It is thought that the new method of photography may have important applications, not only in surgery, but also in metallurgy, by revealing flaws, inequalities and fractures in metals.

Hertz discovered that cathode rays pass through metal films not translucent to ordinary light, and that Dr. Lenard and others have published careful experiments on the subject. Attention has been called to Prof. Zeugen's having photographed Mt. Blanc, in 1885, by the cathode rays. Prof. Röntgen, however, states that the rays discovered by him, which he calls X-rays, are not cathode rays, as they are not refrangible nor affected by magnetic influences, but that they are more probably longitudinal waves in the ether.

While Hertz and Lenard hold that the cathode rays are vibrations in the ether or even light of short wave-length, Crookes and J. J. Thomson have urged that the rays are negatively charged matter traveling with great velocity. M. Perrin reported to the Paris Academy, on December 30th, experiments which tend to show that the latter view is correct, and some relation will probably be found between cathode rays and the X-rays.

PHYSICS.

BY constructing what might be termed a reversed level, A. Toepler obtains an instrument which he calls a 'pressure level.' It consists of a tube bent to a slight angle at its middle point; the two ends are equally inclined to the horizontal. A short column of a light liquid fills the central portion of the tube. It will be readily seen that if the two open ends are connected with two receivers of any sort, the liquid will, by its position, give the difference of pressure in them. This method of differentially measuring pressures, Mr. Toepler applies (*Wied. Ann.*, Vol. 56, 1895) to measure the difference in weight of two columns of air at different temperatures but both under the same pressure. A long series of determinations of absolute temperatures bears witness to the efficacy of this method, and theoretical considerations remove some apparent objections and give to it certain advantages over the ordinary form of air thermometer.